simpleware

converting 3d images into numerical models

Simpleware:

Converting 3D Images into Models for Visualisation, Measurement and Computational Simulation

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# Introduction to Simpleware

Simpleware: The Company

Developers of industry-leading software solutions for the visualisation and analysis of 3D image data.

- Founded in the UK in 2000

- Key Pioneers in image-to-mesh techniques to generate simulation ready models of highly complex structures

- Worldwide customer base supported by a global sales channel

- Winner of:
  - Queen's Award for Enterprise in Innovation 2012
  - Queen's Award for Enterprise in International Trade in 2013
  - Institute of Physics' (IOP) Innovation Award 2013

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE

THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2012

Simpleware Converts 3D Images
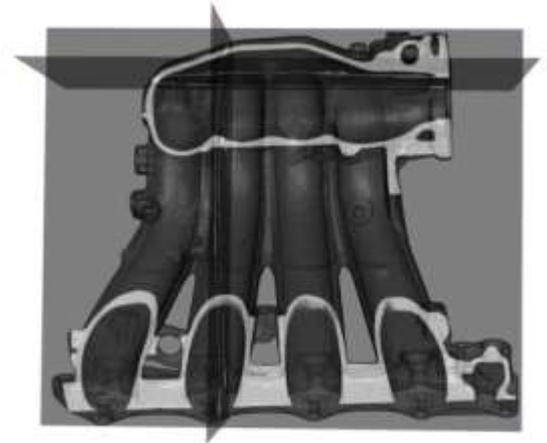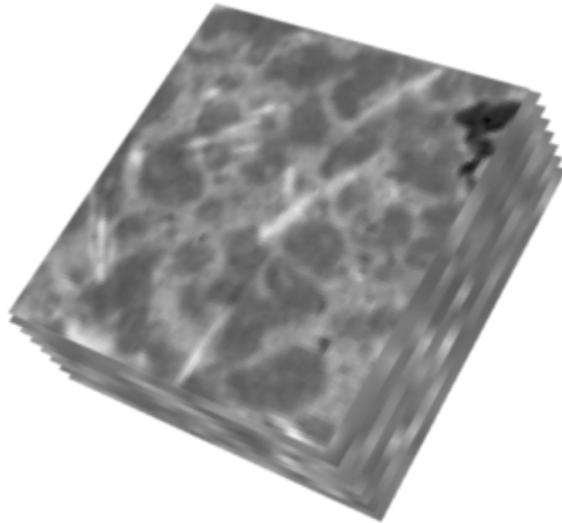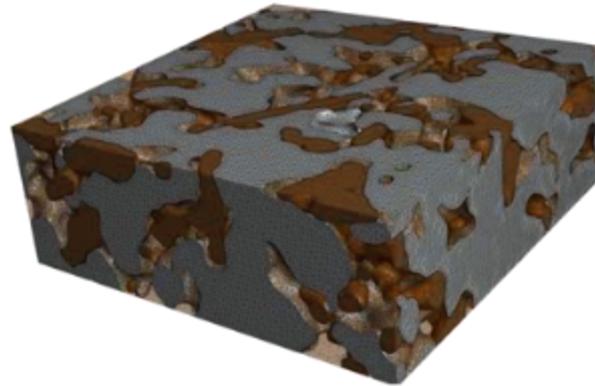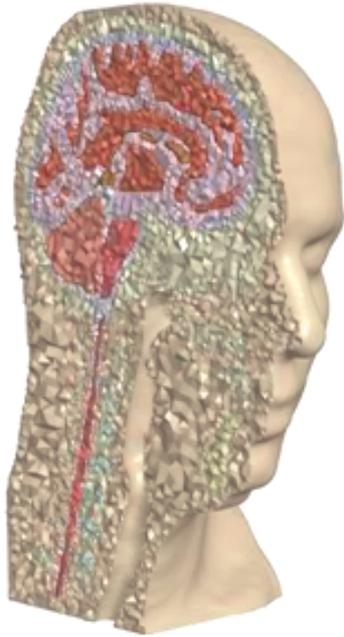
…into 3D Surface and Volume Meshes for Visualization, Measurement and Multi-part Simulation

The Simpleware Solution

- Software/Services for the conversion of 3D images into visualisation **AND** analysis ready, multi-part models

- Can be used for...
  - Any stacked image set
  - Arbitrarily complex topologies
  - Multi-part structures

- Allows the user to...
  - Visualise and Measure
  - Inspect and Assess
  - Send for 3D printing
  - Export to all major CAD/FE/CFD packages for analysis
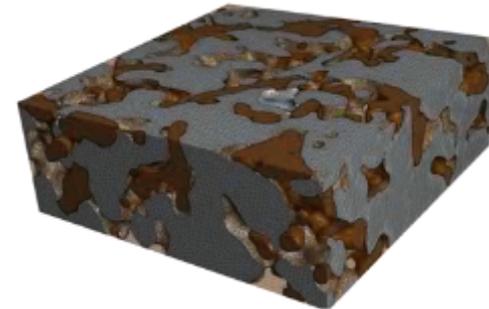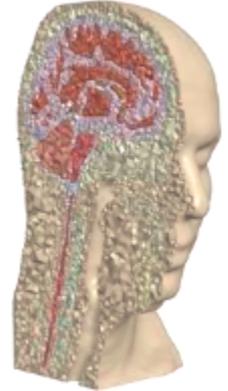
Simpleware's Applications

- ## Biomedical-Biomechanics

  Orthopaedics, Implant Design/Analysis, Physiological Flows, Cardiovascular, Cell Mechanics, Consumer Products...

- ## Materials, Composites, Geotechnical

  Non-Destructive Testing, Characterisation, Analysis, Visualisation, Pore-Scale Flow, Micro-Macro structural Property Prediction, Weld Integrity, Corrosion, Crack Propagation...

- ## Reverse Engineering

  Legacy Parts-CAD or Physical, Components of Interest, As-Built to As-Designed Comparison...

- ## Natural Sciences

  Archaeology, Palaeontology, Functional Morphology...

Almost anything that can be scanned can be modelled!

Software overview

Software Overview

Visualisation, quantification and model/mesh generation from 3D images:

- Visualise 3D image data

- Image processing tools

- Measure/Quantify

- Rapid Prototyping (RP)

- Finite Element Analysis (FEA)

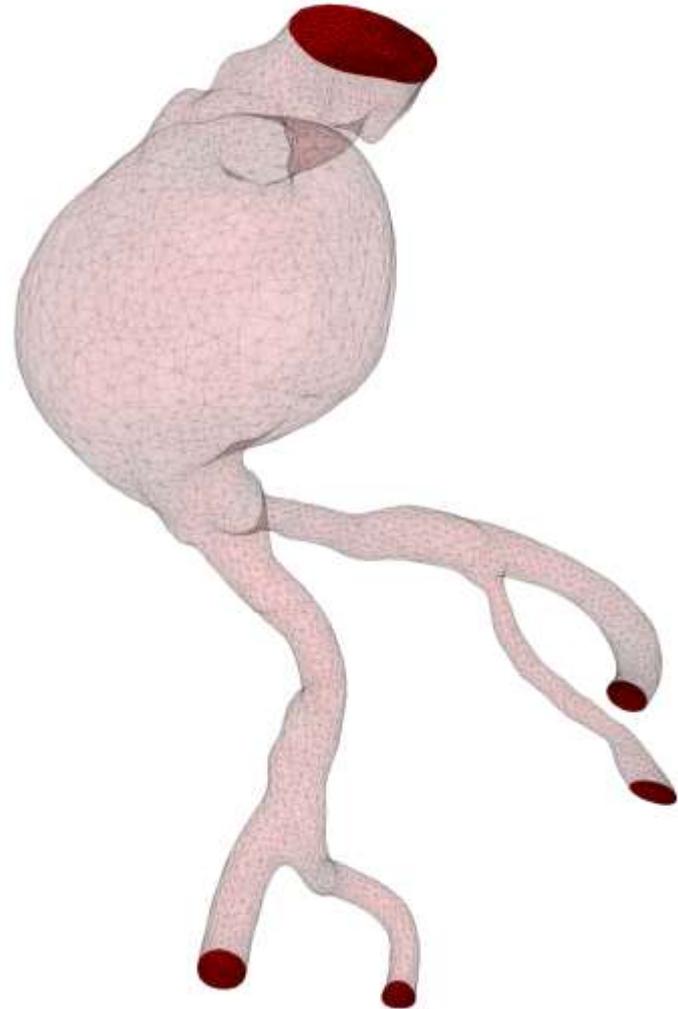- Computer Aided Design (CAD)

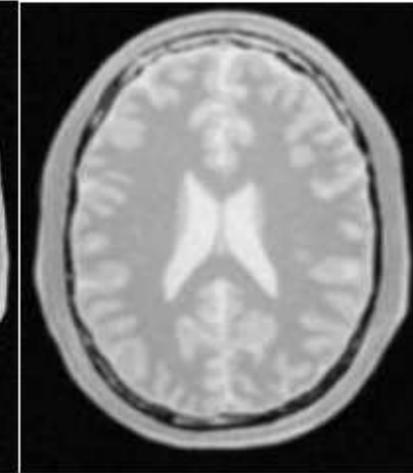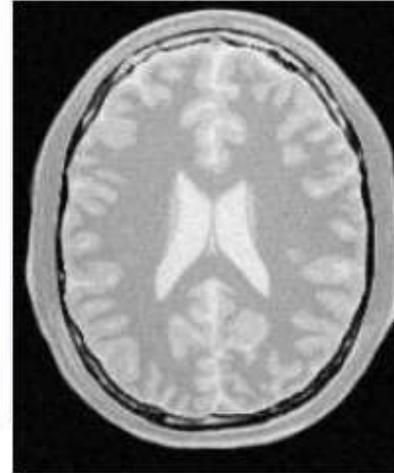- Computational Fluid Dynamics (CFD)

Image import

- CT and MRI
- microCT and nanoCT
- Ultrasound
- Confocal Microscopy
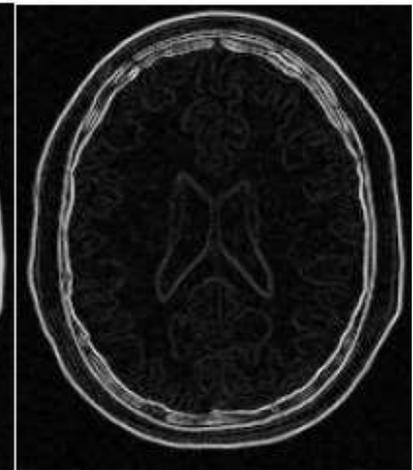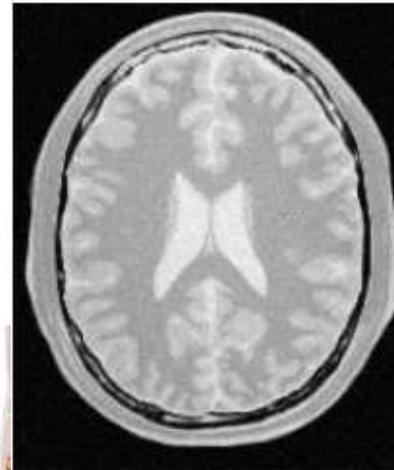- Scanning Electron Microscopy
- Serial images from sectioning

Data manipulation

- Rescale, resample, crop, align

Image filters

- Noise reduction
- Smoothing
- Metal artefact reduction
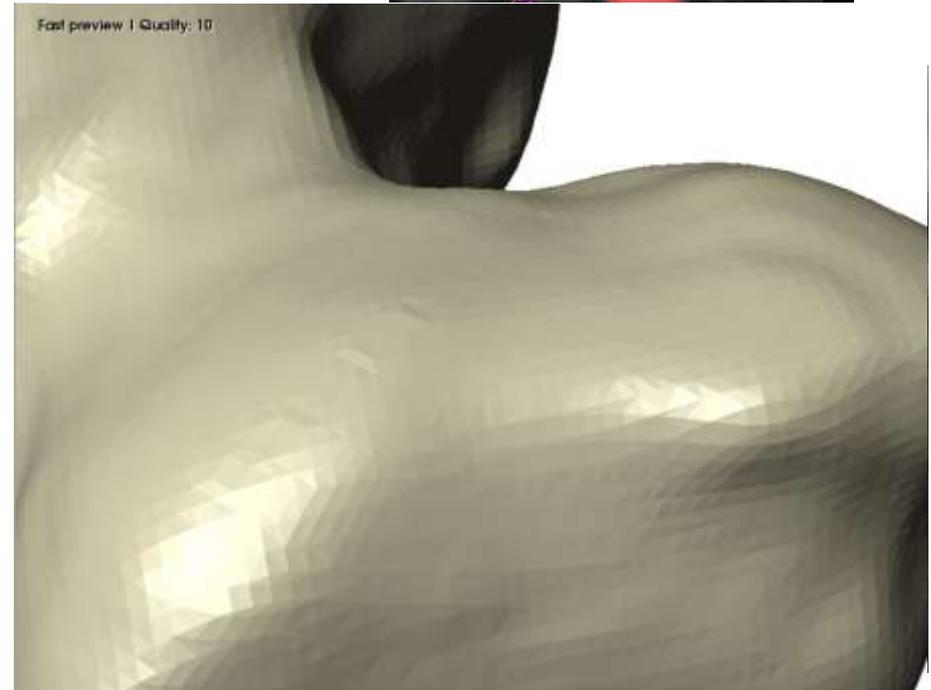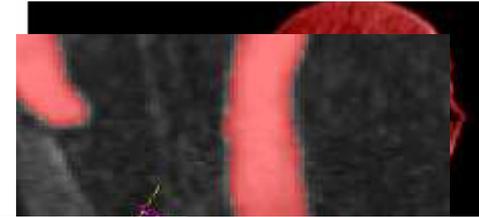
Segmentation tools

- Paint, paint with threshold
- Threshold and floodfill
- Confidence connected region growing
- Magnetic lasso

Mask filters

- Morphological,
- Cavity fill
- Island removal
- Smoothing/ noise reduction

3D editing

- Apply filters on local ROI
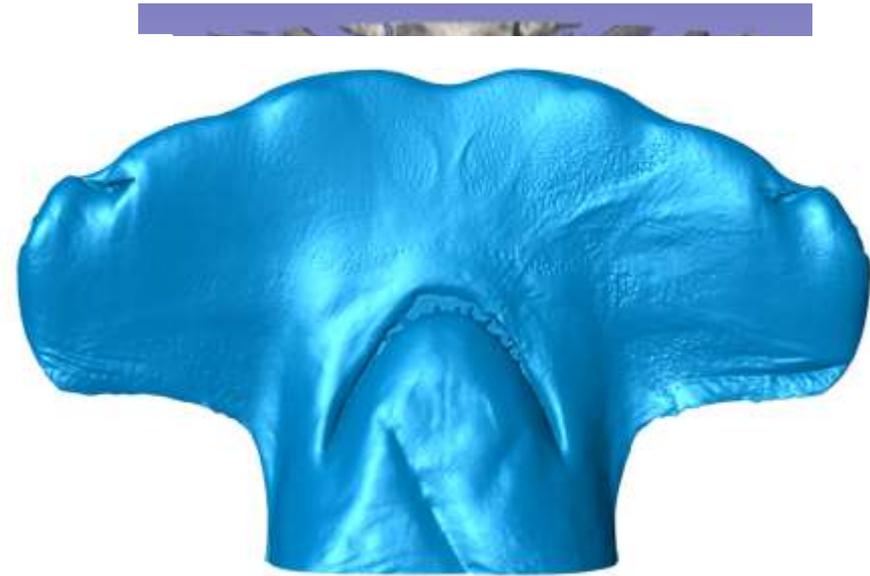- Delete, smooth, erode, close etc...

Fast preview I Quality: 10

Number of voxels:	194680	Minimum GS:	248.44
Mean GS value:	389.50	Maximum GS:	602.09
Standard deviation:	92.59	Volume (mm^3):	99676 (5.28%)

OK

Volume rendering

- Very fast and memory efficien
- GPU rendering supported
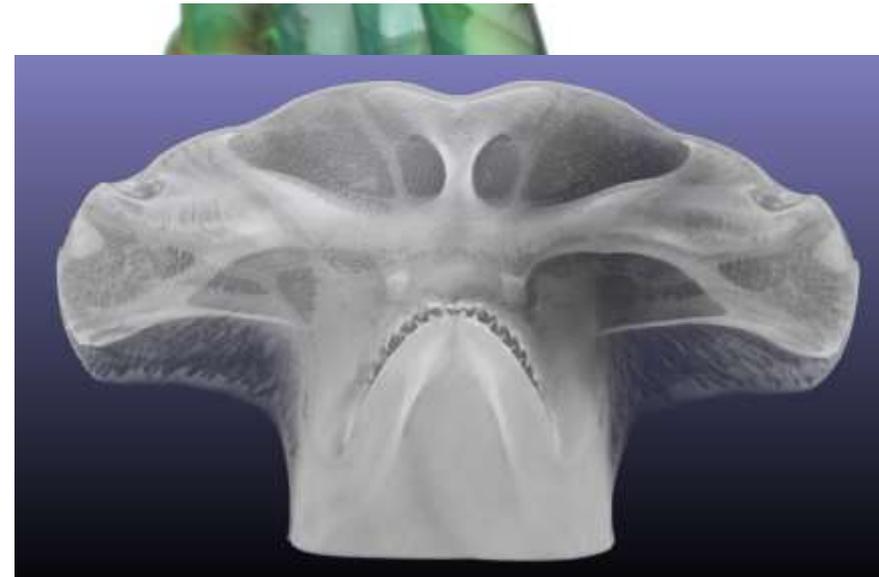- Interactive histogram
- Presets and "Auto guess"

Mask rendering

- Renders segmented mask(s)
- Clipping and opacity settings

Common options

- Background colours
- Lighting
- 3D stereo rendering modes

→ Or combine both!

Interactive tools

- Points, distances, angles
- Recorded with project file
- Histogram and profile line
- Landmarking for musculoskeletal simulations

## Image statistics framework

- Extensive range of measurements
- Volume fractions, surface area, region centre, object orientation …
- Build and share templates
- Custom functions
- Statistics within ROIs
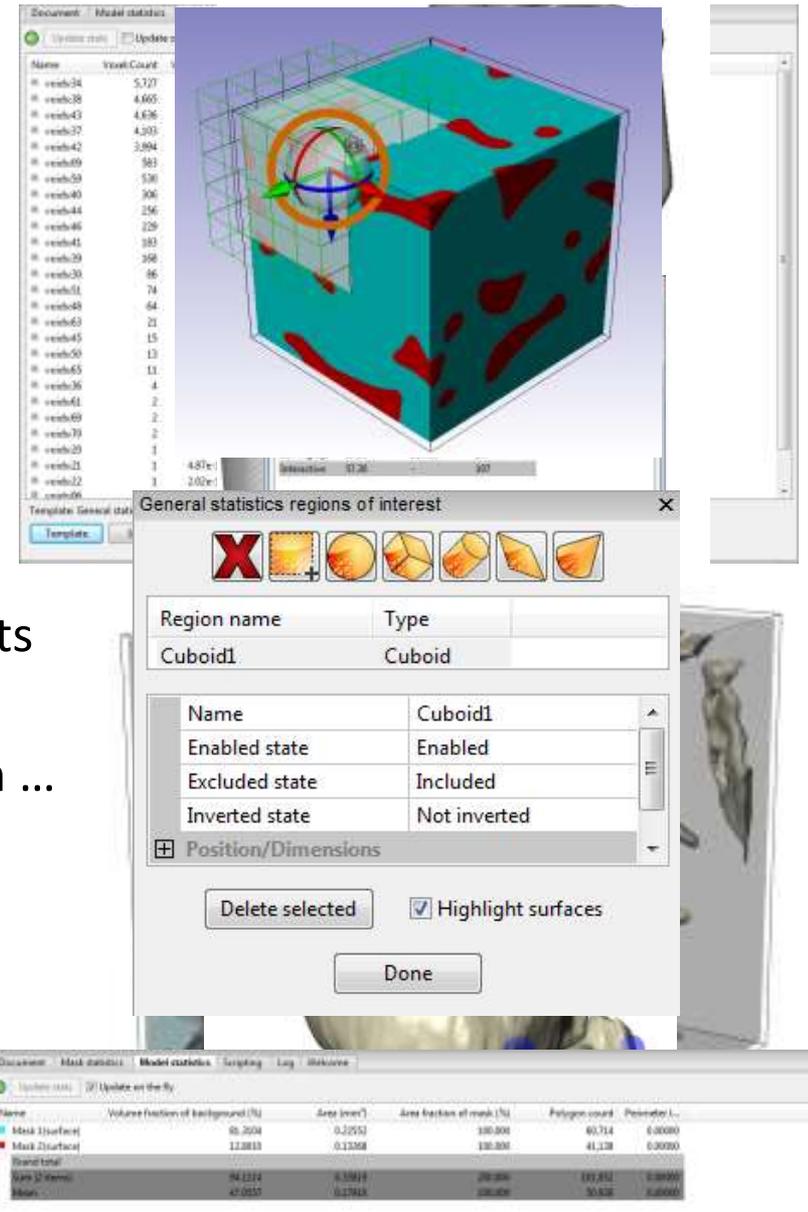
Surface mesh generation

- Volume and topology preserving
- Automated and robust
- Guaranteed watertight
- Automatic handling of multiparts
- Feature based adaptation
- User defined refinement
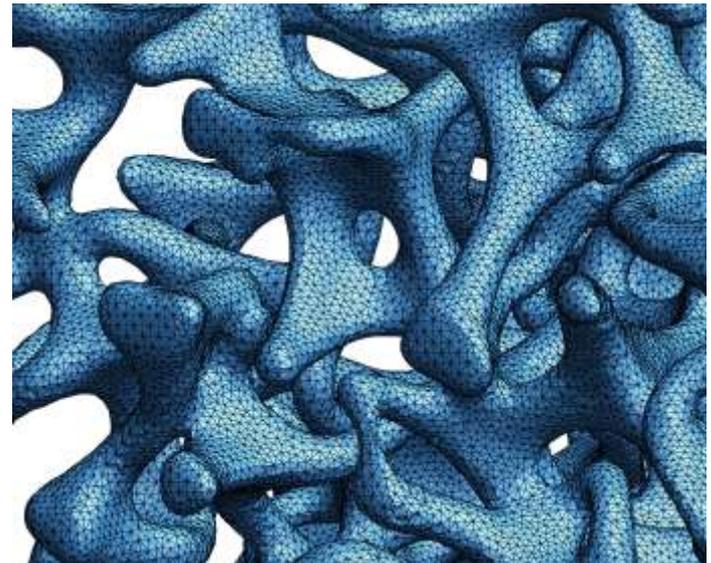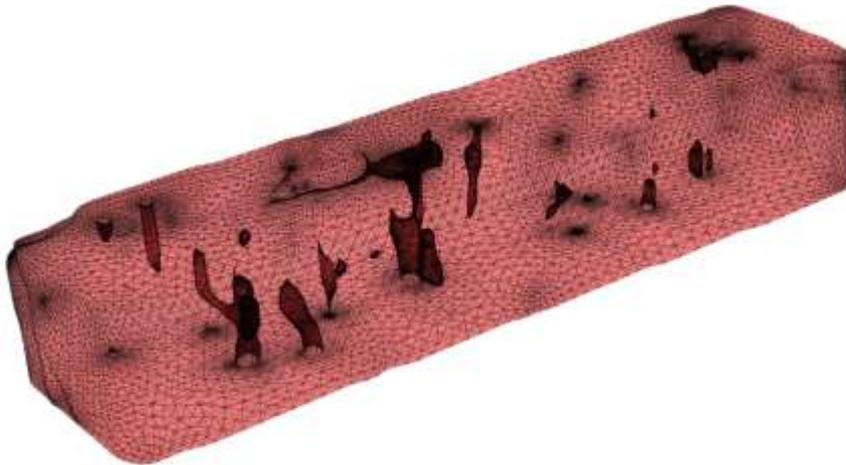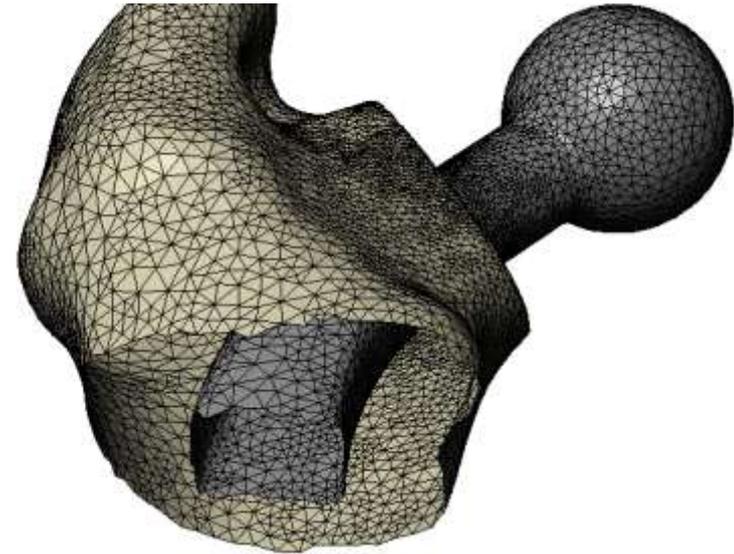
Volume mesh generation with +FE module

- Volume and topology preserving
- Automated and robust
- Choice of algorithms
- Automatic handling of multiparts
- Feature based adaptation
- User defined refinement
- Mesh optimisation
- Contacts, node sets, prism layers for CFD
- Curved quadratic tet elements
- Tet to hex converter
- Greyscale material mapping
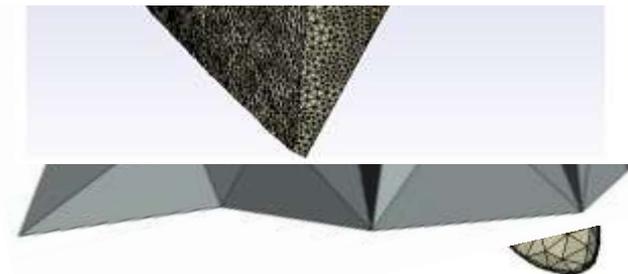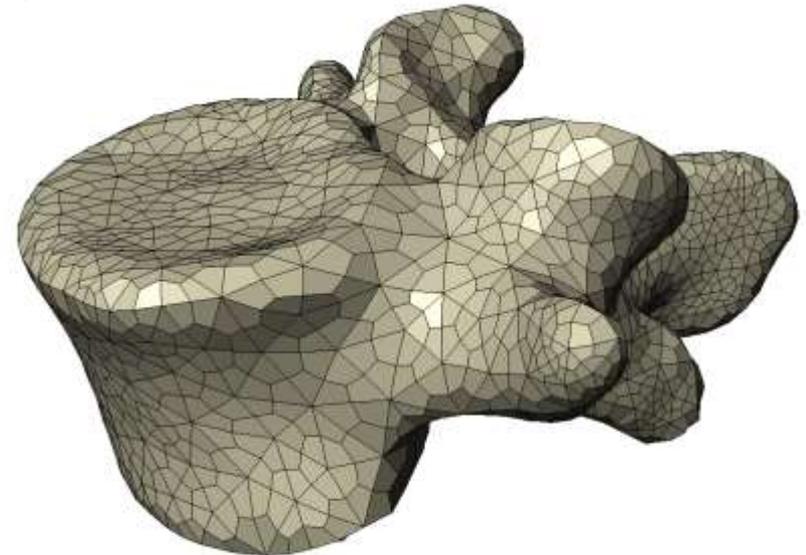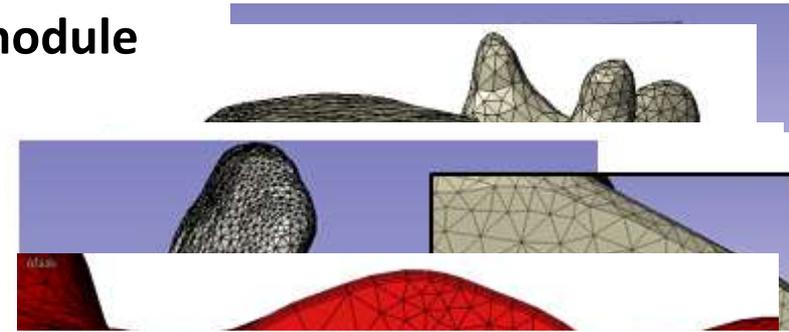
NURBS CAD Model generation with +NURBS module

- Automated NURBS patch fitting
- Choice of algorithms
- Highly accurate conversion
- Export to IGES

CAD ready models for:

- CAD
- FE and CFD applications
- Subject specific device design
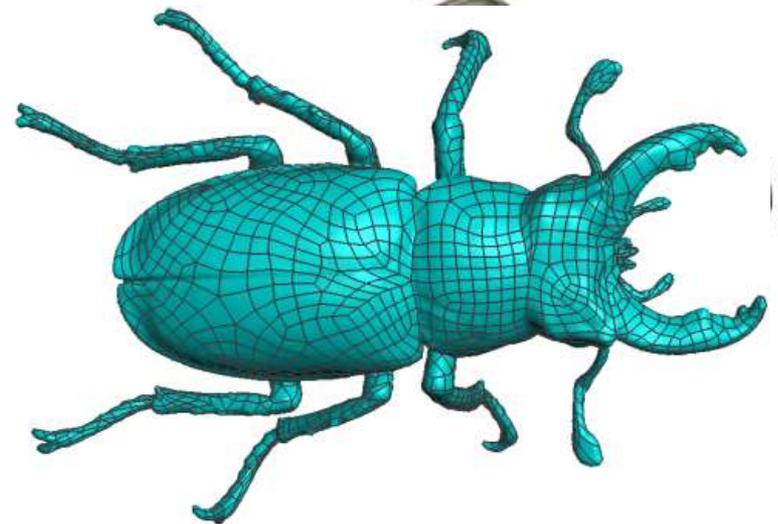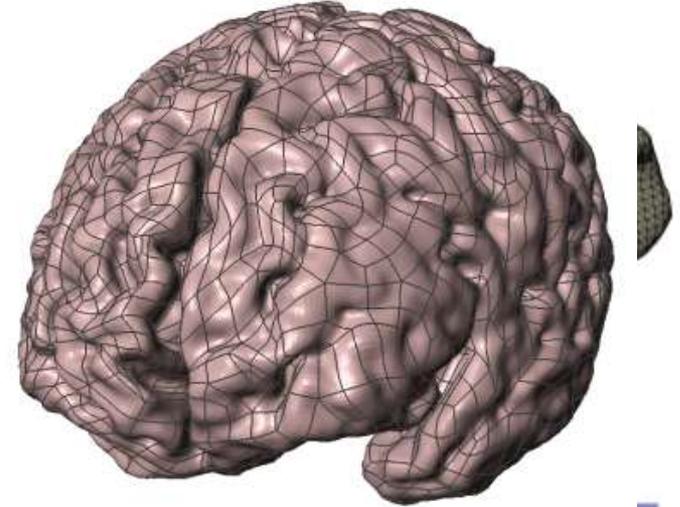
CAD integration with +CAD module

- Fast and easy-to-use tools to combine CAD with image data
- Import CAD files (STL,IGES etc.)
- Interactive positioning
- Constrained positioning
- Robust Boolean operations
- Internal structures for RP

Applications:

- Medical device integration for simulation
- Comparing CAD to image
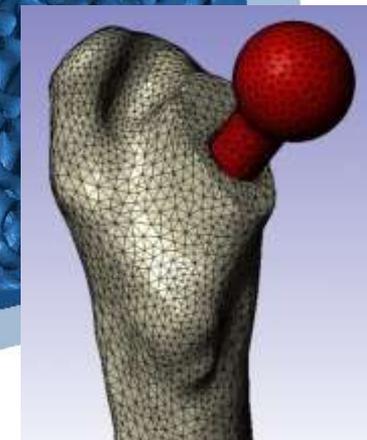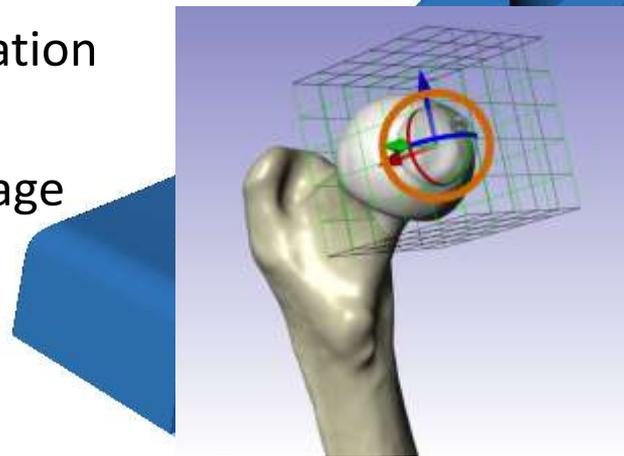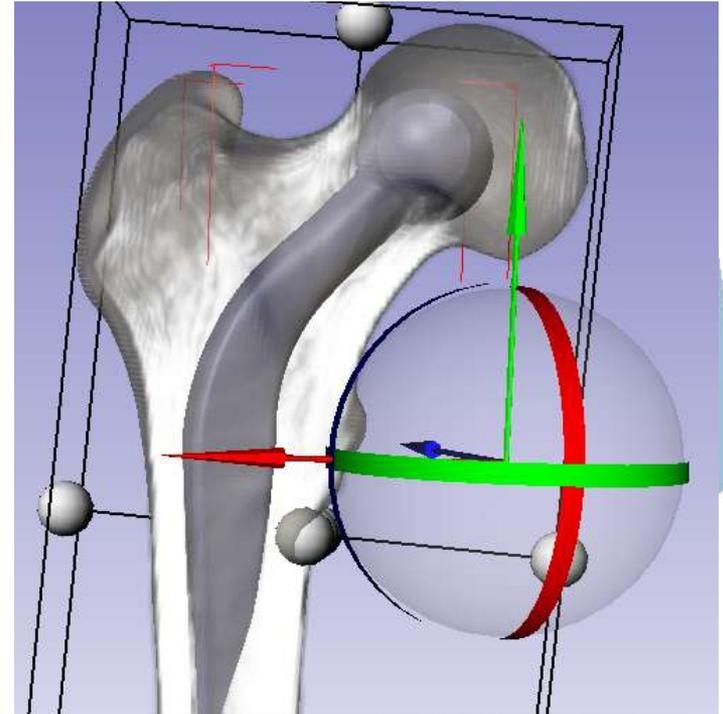
Scripting tools

- All operations can be scriptable
- Python, C#, Java, Visual Basic
- API documentation

record   play

How scripting can help:

- Automate repeatable operations
- Create wizards
- Run scripts from command line
- Build your own plugins
- Macro recording
- Convert log entry to script

Import

CT, MRI, Micro-CT,
Microscopy,
Ultrasound, etc. ….

Simpleware

ScanIP
Image processing, segmentation, visualisation and measurements

+FE module
Automated and robust multipart FE +CFD meshing

+NURBS module
Automated NURBS patch CAD model generation

+CAD module
Integrating CAD into image for meshing and visualisation

Export

Surface meshes
e.g. STL

Volume meshes
e.g. FE & CFD

CAD models
e.g. IGES

Key Features

Smoothing – Topology Preservation

- Accuracy of 3D model from segmentation to smooth 3D surface/volume mesh

Unsmoothed voxel model

Traditional non-topology preserving smoothing

Simpleware topology preserving smoothing

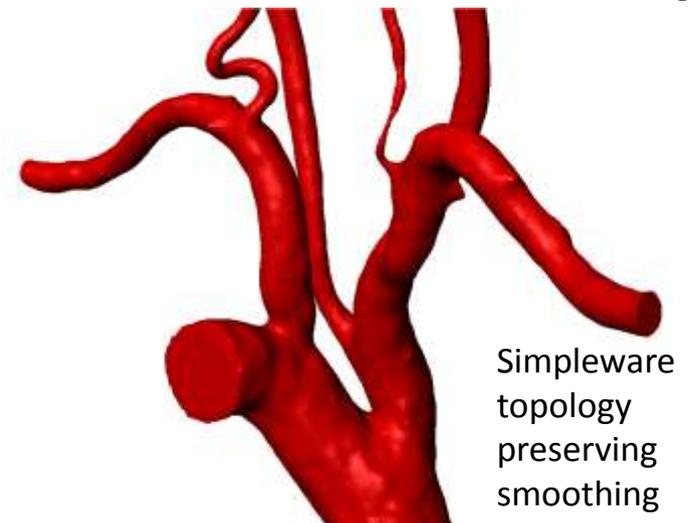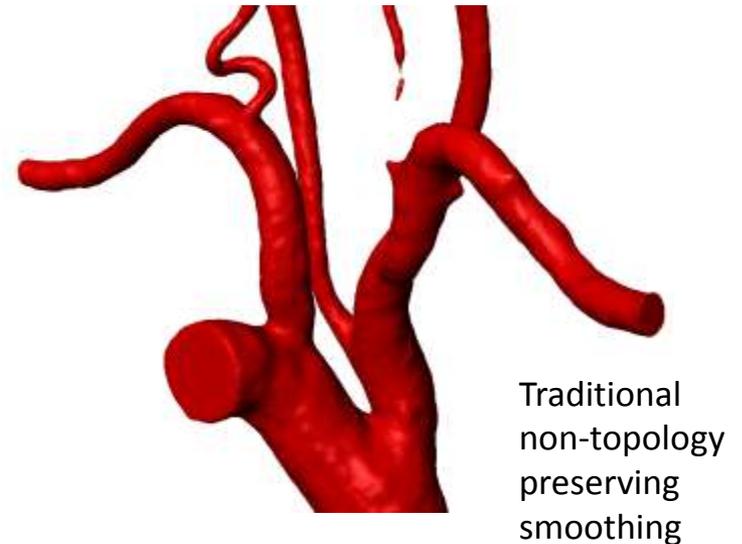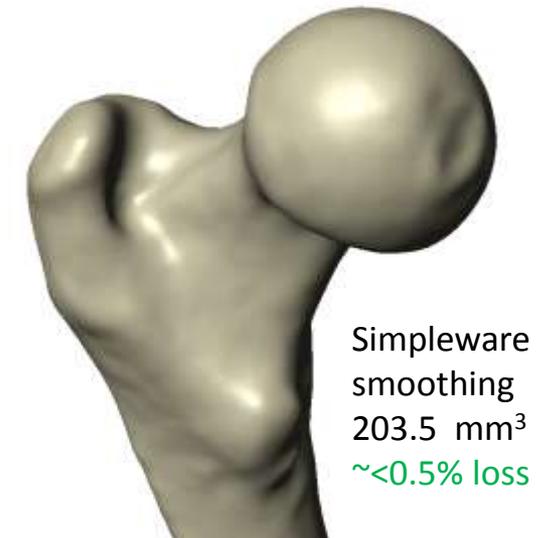# Smoothing – Volume Preservation

- Accuracy of 3D model from segmentation to smooth 3D

Unsmoothed voxel model
204 mm^3

Traditional smoothing
193.9 mm^3
~5% loss

Simpleware smoothing
203.5 mm^3
~<0.5% loss
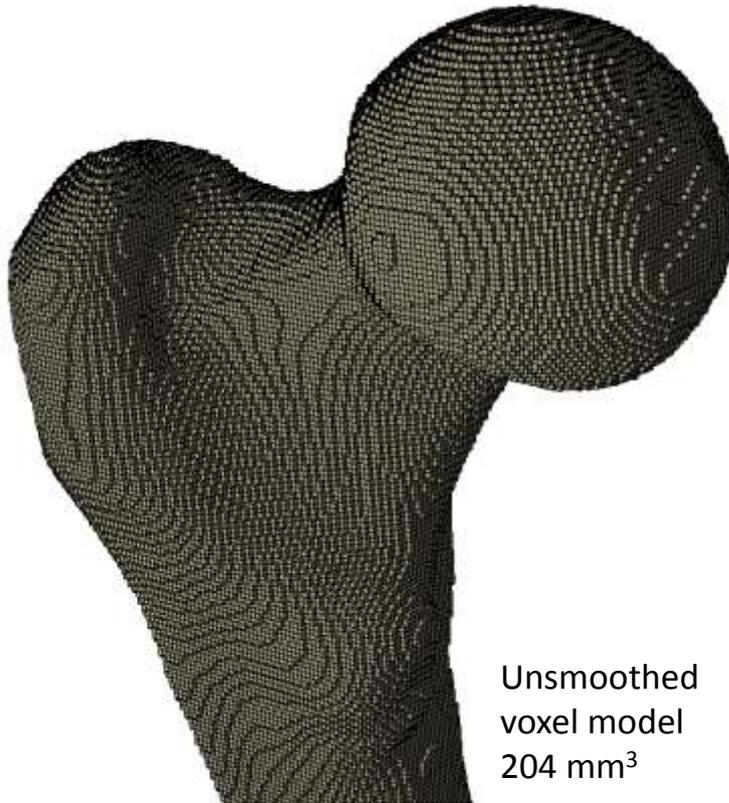
Automatic handling of multiparts

- Smoothing and meshing multiple segmented regions
- Important to maintain interfaces from segmentation to model
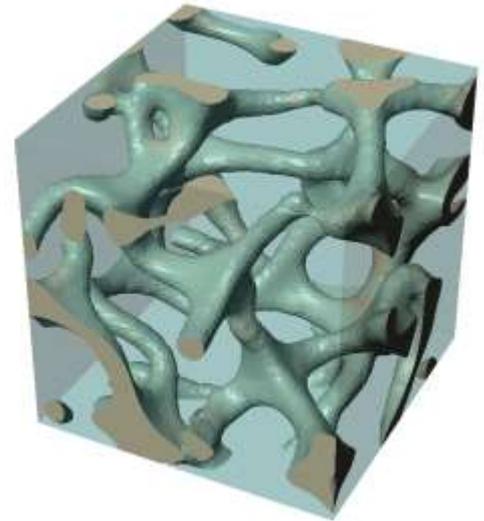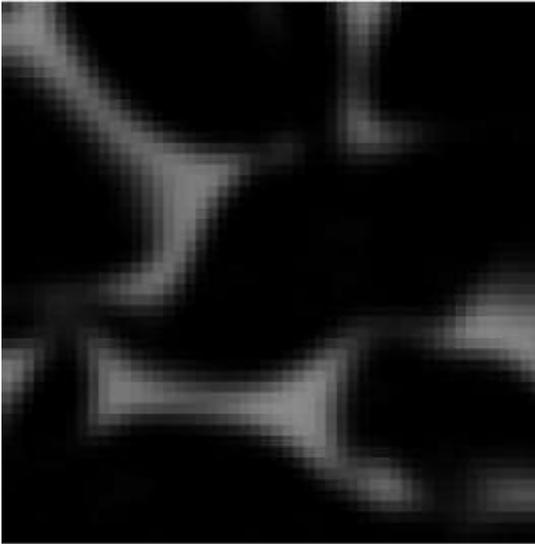
Automatic handling of multiparts

- Traditional part-by-part approaches risk poor meshing, gaps/overlaps, non conforming interfaces.
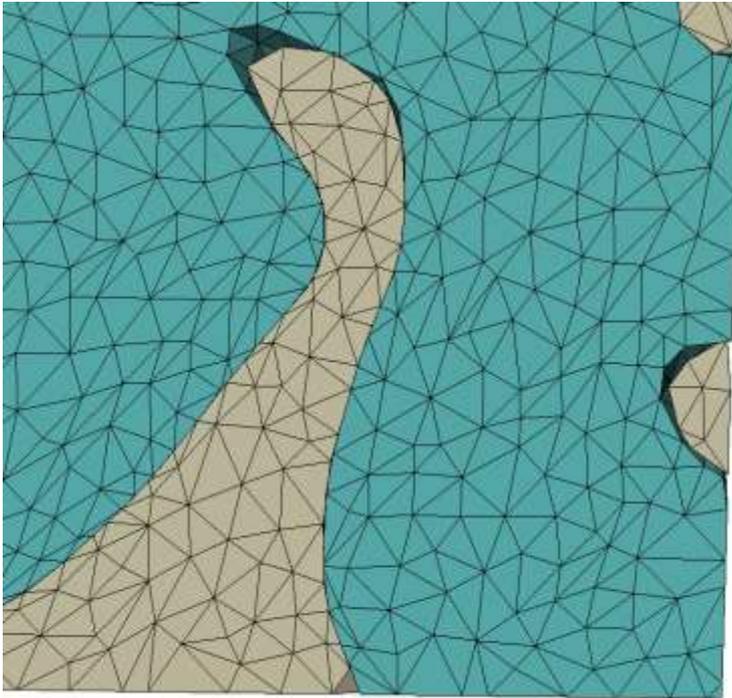
Traditional approach
Build parts one by one
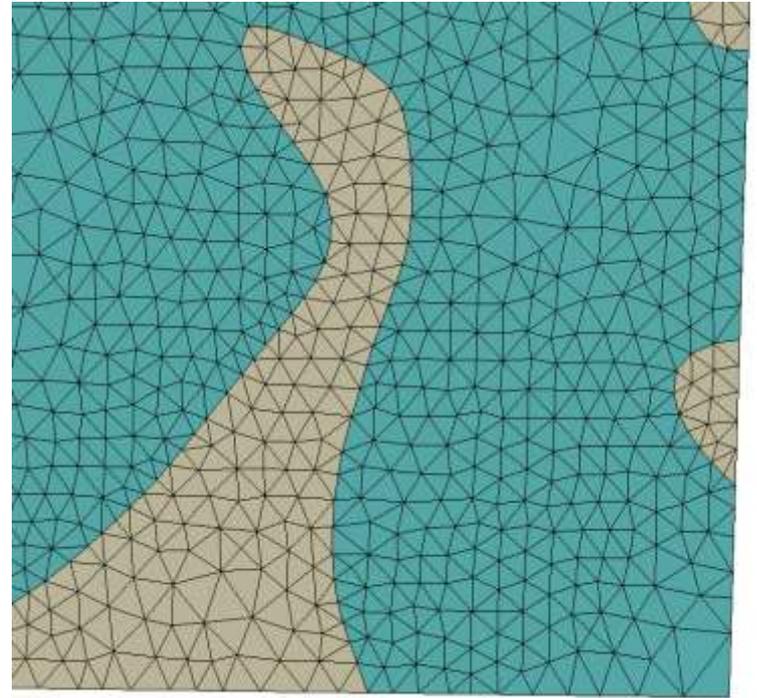
Simpleware algorithms

Adaptive Mesh Controls (+FE Free)

Compound coarseness
(-50 = coarse, 0 = ScanFE Grid surface, +50 = fine)   25
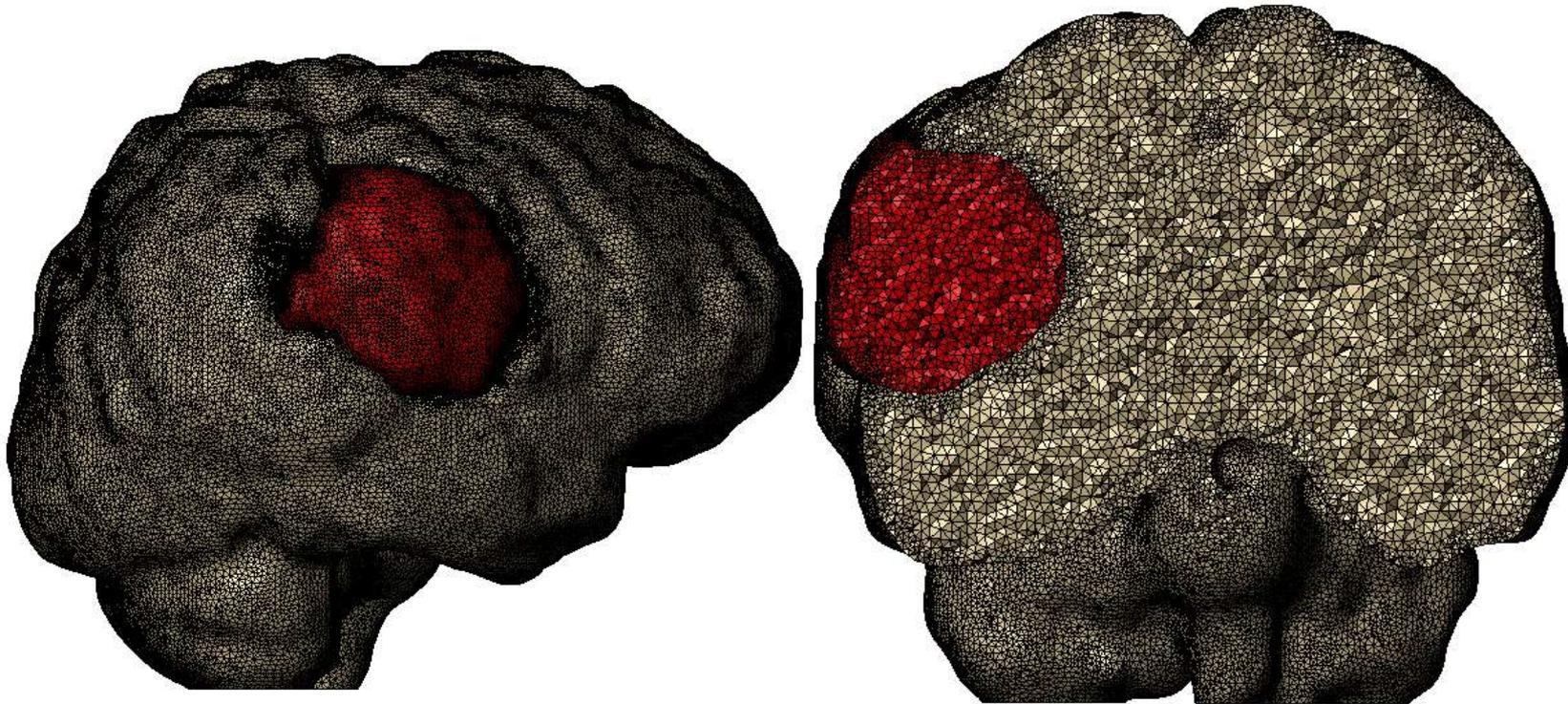
Elements = 973k
Nodes = 190k
Aspect Ratio = 1.5 / 5.8

Adaptive Mesh Controls (+FE Free)

Compound coarseness
(-50 = coarse, 0 = ScanFE Grid surface, +50 = fine)

-50
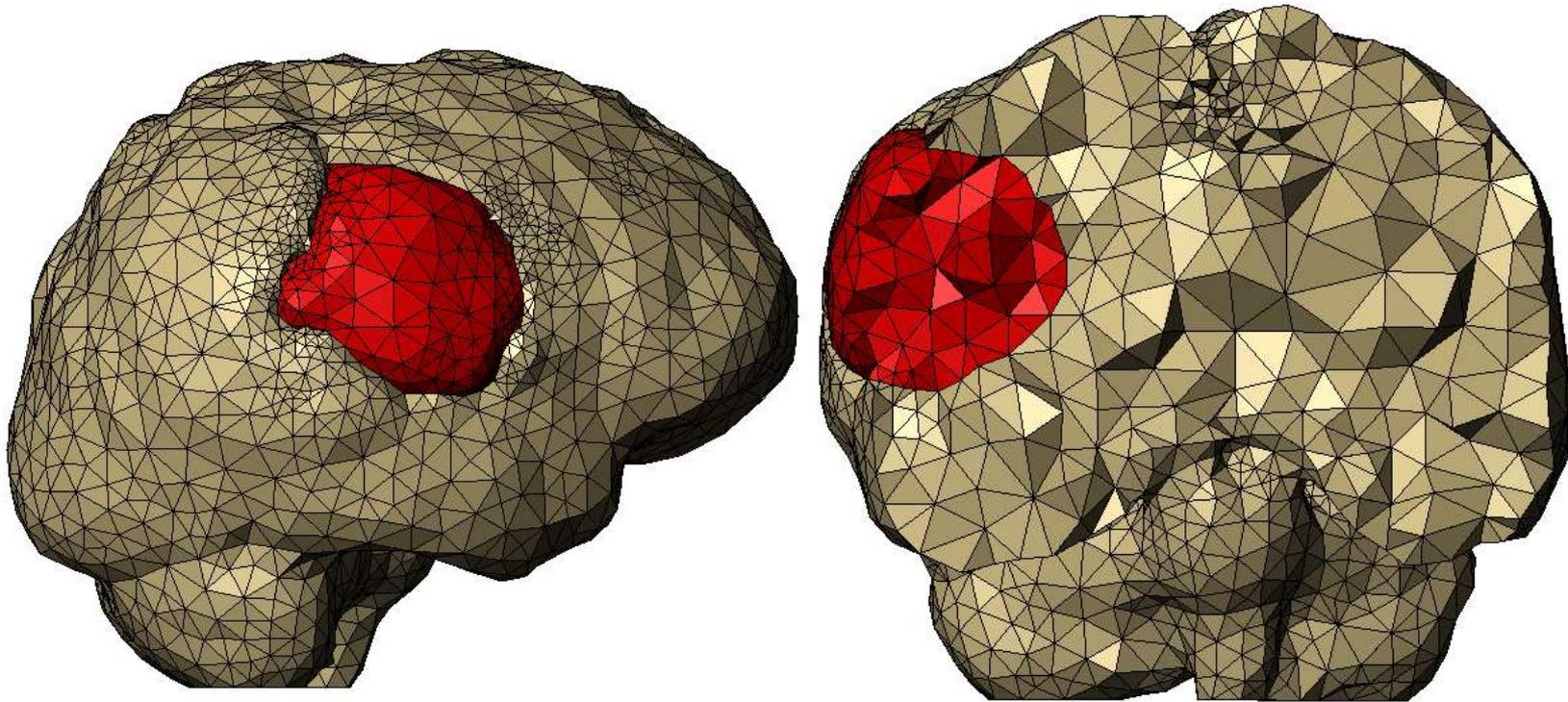
Elements = 30k
Nodes = 7k
Aspect Ratio = 1.7 /4.8

Case study

Head Model for Realistic Simulation

- *In vivo* MRI scan of 26 year old male

Head Model for Realistic Simulation

- *In vivo* MRI scan of 26 year old male

- Segmentation
  - Threshold, floodfill and filters
  - Segmentation of 12 structures

In collaboration with: ARUP

Young et al, 2008. An efficient approach to converting 3D image data into highly accurate computational models. Philosophical Transactions of the Royal Society A, 366, 3155-3173.

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- Multi-part mesh generation
  - 12 structures meshed simultaneously
  - Multipart smoothing with conforming interfaces
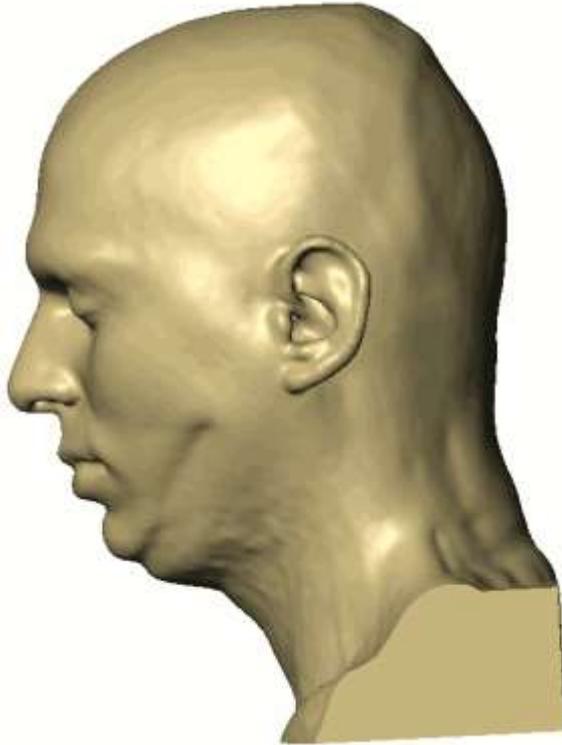
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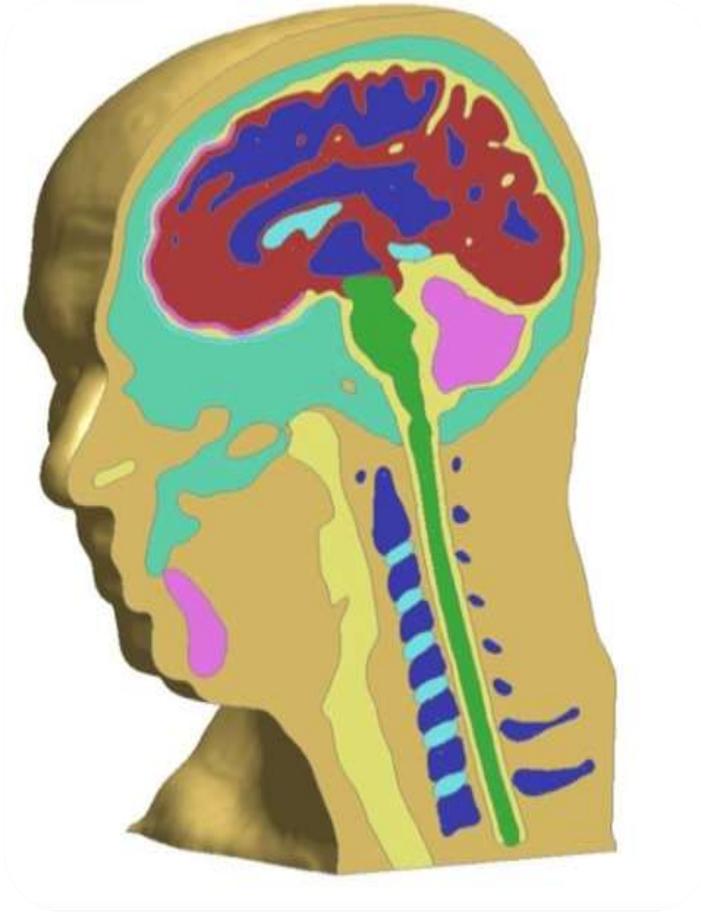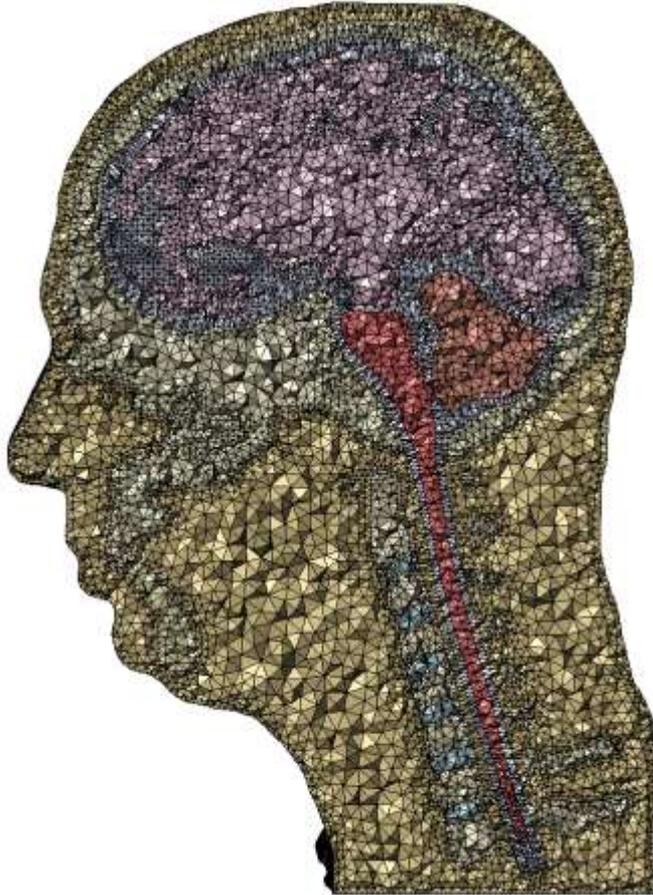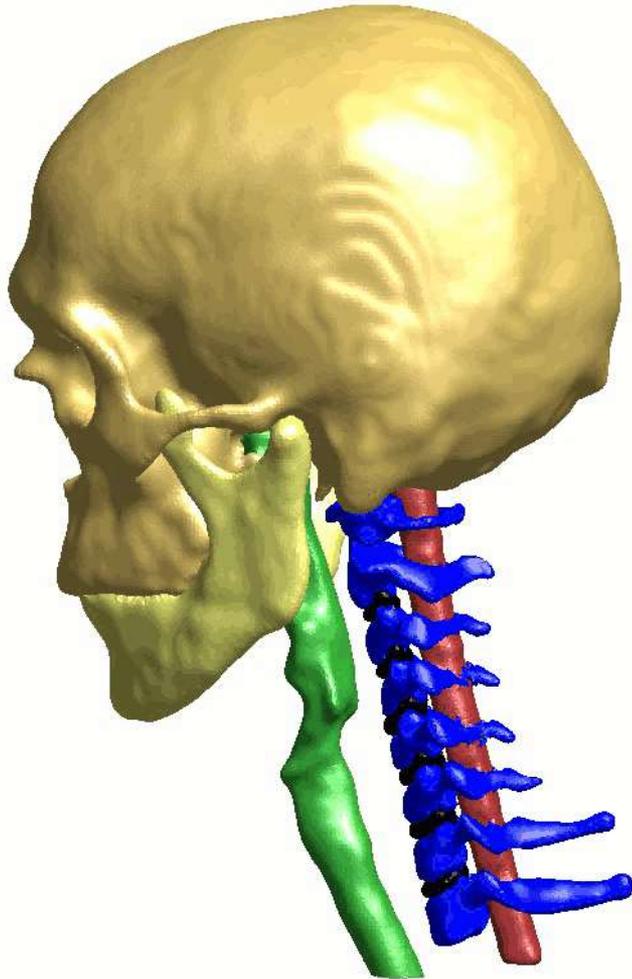
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- FE analysis in LS-Dyna
  - Boundary conditions and loads
  - Response to blast wave and to dynamic loading conditions

In collaboration with: ARUP

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Head Model for Realistic Simulation

OASYS D3PLOT: SIMPLEWARE HEAD 28
1: Max H6616603 : 0.000000E+00

VON_MISES_STRESS

(Mid surface)

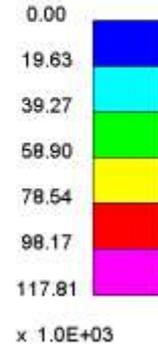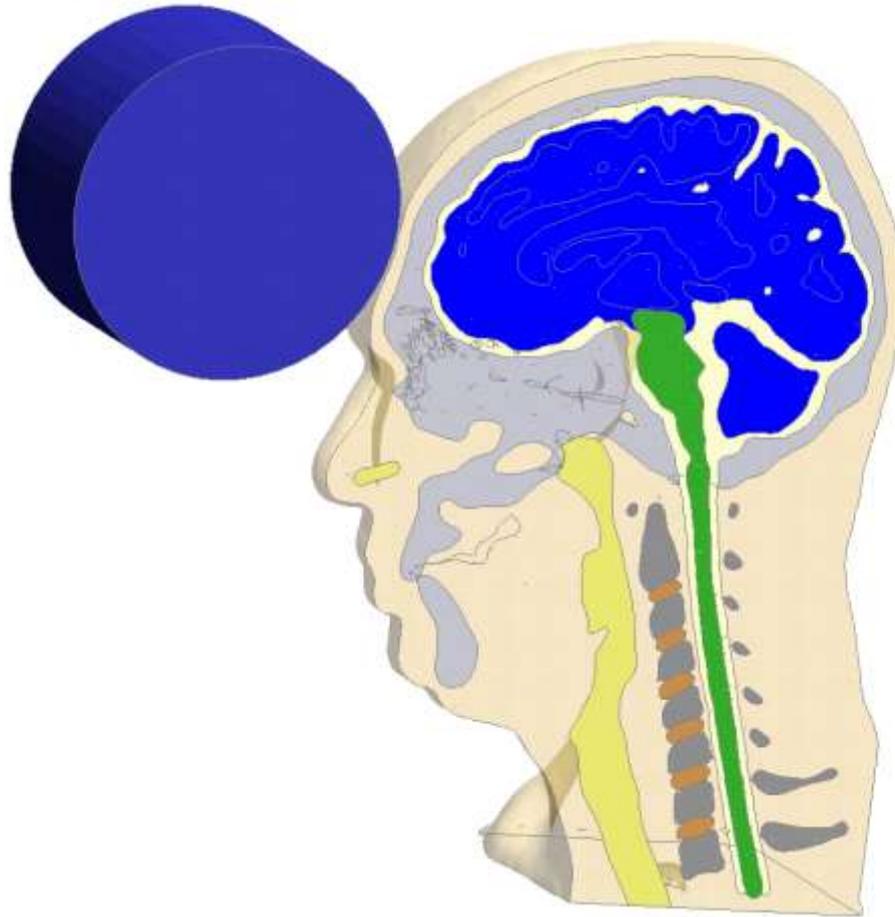| 0.00 |
|---|
| 19.63 |
| 39.27 |
| 58.90 |
| 78.54 |
| 98.17 |
| 117.81 |

x 1.0E+03

.000000000

In collaboration with: ARUP

Young et al, 2008. An efficient approach to converting 3D image data into highly accurate computational models. Philosophical Transactions of the Royal Society A, 366, 3155-3173.

Extended Head Model with Helmet

- Import helmet components
  - Outer Shell
  - Pads
  - Face guard

- Positioning
  - Initially Interactively with 3D view
  - Then fine tuning through specified rotations and translations

- Combined models
  - Football helmet
  - Military helmet

*In collaboration with: **Naval Research Laboratory** and **SIMULIA***

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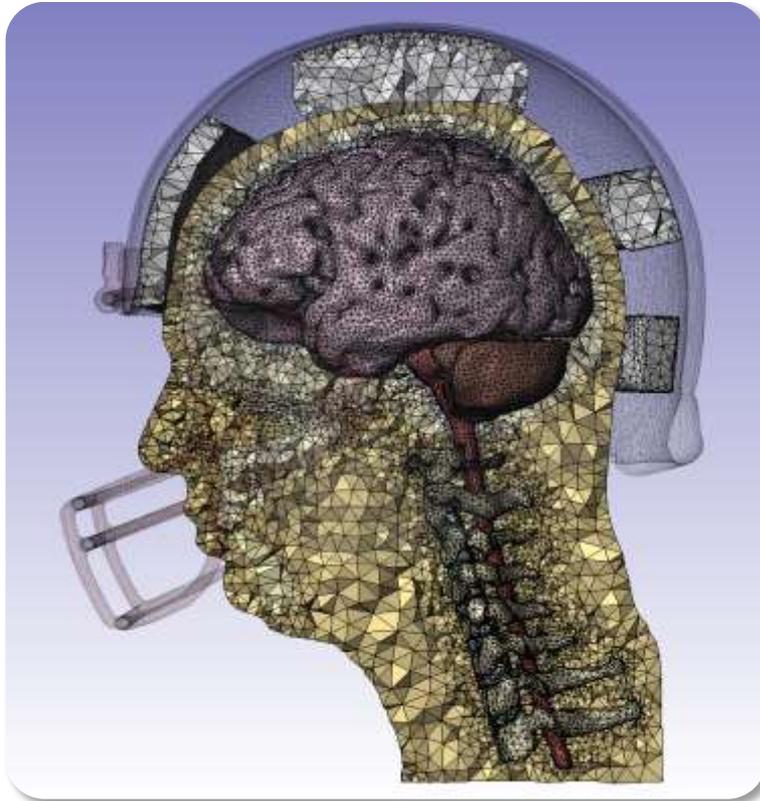simpleware

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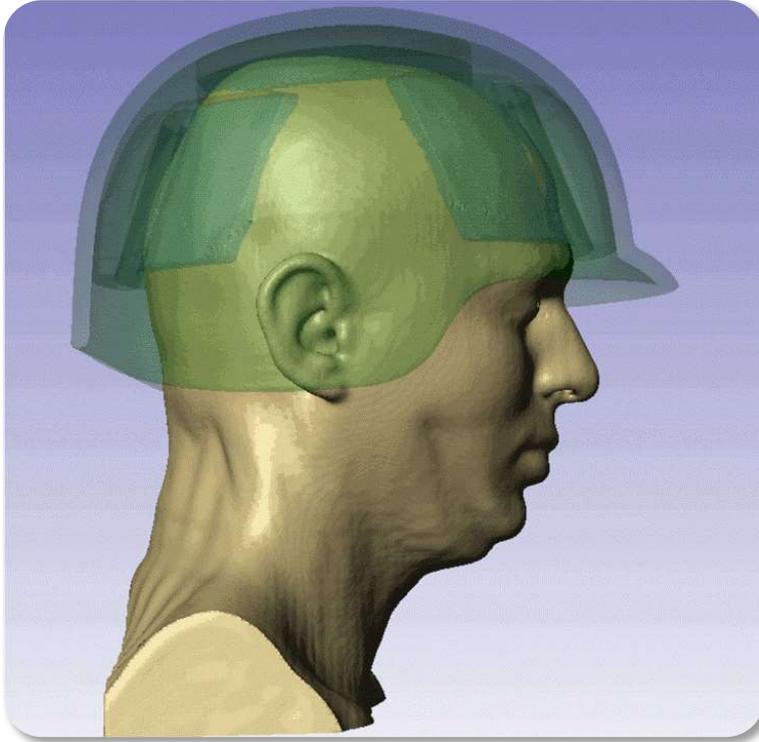# Extended Head Model with Helmet

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Summary

Reliable, Robust and Accurate

- Established/tried & tested commercial code
- Efficient, fast, stable
- Code based on combination of proprietary algorithms and published literature
- Rapid and responsive development
- Guaranteed generation of watertight surfaces
- Fully automated surface/volume meshing
- High mesh quality suitable to direct use in FE/CFD

Visit www.simpleware.com to get a 30 day trial version
Includes tutorials and example data
Also includes full technical support